



Airport & Aircraft Safety R&D Notes

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FAA's Airport & Aircraft Safety R&D Division

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Air Transportation Center of Excellence Holds Phase I Symposium

On November 14 and 15, 2000 the FAA Airworthiness Assurance Center of Excellence (AACE) presented a Phase I symposium to review a significant number of research accomplishments achieved during the first three years of operation. The Air Transportation Centers of Excellence (COE) partnerships reflect a winning concept, initiated by Congress and taps into the expertise of aviation scientists across the entire country.

The symposium was hosted by the FAA Transport Airplane Directorate, Northwest Mountain Region, and The Boeing Commercial Airplane Company. The meetings were held at the Boeing-Longacres Training Facility in Seattle, Washington.

At this symposium the AACE aviation community gathered to share program findings and exchange ideas that relate to aircraft safety. Program information presented by teams of experts covered the full spectrum of aviation safety. Research activities highlighted included, but were not limited to: aircraft inspection, maintenance and repair; propulsion and fuel systems safety; crashworthiness; advanced materials; validation, and nonstructural systems.

The sessions included presentations by AACE distinguished members representing government, academia, and the aviation industry. There are eight core universities in this Center with twenty additional university affiliates and a significant number of industry and other partners. The core university members are: Iowa State University, Ohio State University, Arizona State University, Northwestern University, University of Dayton, University of Maryland, Wichita State University, and University of California-Los Angeles.



Don Riggan, Manager, FAA Northwest Mountain Region
With Chris Seher, Director, Airport and Aircraft Safety
R&D Division

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At the symposium, AACE received recognition and praise from prominent FAA Managers. Ms. Mary Powers-King, FAA Deputy Director of the Office of Aviation Research, stated that she is a "strong proponent of partnerships with industry and academia" such as this Center represents. Mr. Don Riggan, FAA Manager of the Northwest Mountain Region, works directly with the rules and regulations of airplane standards, and spoke of the "FAA's goal for an 80% accident rate reduction by the year

2007" and its correlation to AACE endeavors. He added that Centers provide the FAA with the "horsepower to meet our common goals, as no one can do it alone. We must work together to make it all happen effectively." Riggins also acknowledged the amount of "forethought it has taken to put this program together" and commended the organization for its dedication and hard work.

Other distinguished speakers included Mr. Jack McGuire, Director of Research and Development, Boeing Corporation, and Mr. Chris Seher, Director, FAA Airport and Aircraft Safety R&D Division. Others acknowledged at the event for their significant contributions to the program included Ms. Patricia Watts, Program Director for the FAA Centers of Excellence, and Dr. Catherine Bigelow, AACE Program Manager. The FAA Centers of Excellence Program is managed by AAR-400, through Mr. Chris Seher, at the William J. Hughes Technical Center, Atlantic City International Airport, New Jersey

Research of interest highlighted at the symposium included a description of a new advanced ultrasonic inspection technology and an imaging scanner for adhesive bond inspection being developed by the Ohio State University interdisciplinary team of Professors Stan Rokhlin and Herman Shen with a group of students. To maintain transportation safety, the use of polymer adhesives requires nondestructive evaluation (NDE) technology that quickly and reliably detects an adhesive bond quality and its environmental damage in the field.

The OSU AACE team members are closely interacting with industrial partners Boeing, BFGoodrich, United Technologies, and small businesses. The essence of the technique is in simultaneous inspection by two ultrasonic beams: normally and obliquely incident on the adhesive/adherent interface, thus introducing a state of shear stress on the interface and point-by-point measurements of the bond line physical parameters (thickness, stiffness and others). During Phase I of this research, the technology was demonstrated using ultrasonic measurements on adhesive bonds before and during environmental degradation and gauging ultrasonic tests with destructive measurements. It was found that environmentally induced distributed damage at the adhesive/adherent interface can be detected using this method.

The prototype of the digital scanning system has been developed. Plans call for a two-year technology-transfer phase that includes technology validation at the FAA NDI Validation Center, field testing, and technology transfer for system commercialization.

Patricia Watts, AAR-400, (609) 485-5043

Full Scale Ground Based Inerting Testing

Significant emphasis has been placed on fuel tank safety since the TWA Flight 800 accident in July 1996. Since the accident, the Federal Aviation Administration (FAA) has issued numerous Airworthiness Directives to correct potential ignition sources in fuel tanks, and has conducted research into methods that could eliminate or significantly reduce the exposure of transport airplanes to flammable vapors. The latter has been in response to new FAA policy that strives to eliminate or reduce the presence or consequences of flammable fuel tank vapor. This has included fuel tank inerting, which is commonly used by the military. However, the systems weight and resource requirements and low dispatch reliability have indicated that military fuel tank inerting systems would not be practical for application to transport airplanes.

Recently, a fuel tank inerting working group was formed by the Aviation Rulemaking Advisory Committee (ARAC) in response to a recent proposed rule change that would require a reduction in commercial transport airplane fuel tank flammability with an emphasis on center wing and body style tanks. This working group has been charged with developing regulatory text as well as to determine cost and benefit of the proposed rule change. AAR-422 personnel directly supports this high priority FAA initiative with both project work and committee support.

Recent FAA research undertaken by AAR-422 has evaluated state-of-the-art hollow fiber membrane (HFM) gas separation technology. HFM technology could be used to generate on site Nitrogen Enriched Air (NEA) in a cost-effective manner to inert fuel tanks while the aircraft is operating at the airport gate, known as Ground Based Inerting (GBI). HFM technology could also be used to develop on-aircraft inerting systems that are much lighter with greatly improved dispatch reliability.



Nitrogen Enriched Air (NEA) Generator for Ground Based Inerting

The FAA has focused research to support two primary methods of fuel tank protection, both involving fuel tank inerting. Ground-based fuel tank inerting would involve some combination of fuel scrubbing and ullage washing with NEA generated at the airport while the airplane is on the ground and could be applied to all or most operating transport airplanes. It would only use ullage washing if applied to a limited number of airplanes, such as only those with heated center wing tanks (HCWTs). On aircraft fuel tank inerting would involve ullage washing during some or all aircraft operations with a system that generates NEA on the aircraft with the auxiliary power unit (APU) and/or engine bleed air.



Eight Channel Oxygen Analysis System

Ground-based inerting involves fuel tank inerting on the ground only. Until recently, it was in concept only. However, GBI has recently been demonstrated on a Boeing 737 BBJ in a joint FAA/Boeing GBI ground and flight test program. During the tests, the primary instrumentation was an 8-channel oxygen analysis system developed for the testing by AAR-422. Although limited in scope, the tests illustrate the ability of GBI to provide fuel tank explosion protection. However, more work needs to be done to develop and demonstrate the GBI concept, in particular, an on-board system. In this regard, AAR-422 has negotiated to purchase a Boeing 747 SP from United Airlines that has been decommissioned

from airline service to allow for a more extensive development analysis of GBI. At this point AAR-422 plans to take delivery of the aircraft on or about March 1, 2001.

The research would involve two major phases. The first being an examination of the use of ground supplied NEA to inert a large commercial airplane fuel tank and a study of what conditions affect the ability of the fuel tank to stay inert. The second phase of the work involves soliciting on-board NEA generation systems to examine the state-of-the-art of OBIGGS as it relates to commercial aircraft systems and operations.

To help better quantify the cost and benefits of GBI, the aircraft center wing section would be instrumented with thermocouples as well as sample ports for oxygen and hydrocarbon analyzers to examine the ability of a ground based NEA supply to maintain an inert ullage space under a variety of operational ground conditions. These conditions include long ground layovers with and without “packs” operating,

high winds and inclement weather, and day and NEA temperatures. This test article would also be utilized to develop effective distribution systems and devices that could improve the time benefit of ground supplied NEA. Each testing would involve inerting the aircraft's CWT with a ground-based NEA supply collocated with aircraft, and then examining how a specific condition effects the oxygen concentration in the fuel tank. Some tests may involve taxiing or towing the aircraft to another airport location after inerting to obtain the desired wind condition. At this point, AAR-422 is planning on a 6-10 week lay up period for the aircraft modification and instrumentation starting in March 2001. This will be followed by a 12-16 week test plan commencing in May 2001.



Hose Reel Equipment for Ground Based Inerting

The next phase of the testing would involve soliciting proposals for OBIGG systems given the resources available on the aircraft. The system would be sized to inert the empty volume of the B-747 CWT within a turn around time frame. A prototype system would be based on such factors as cost of operation, weight, and perceived reliability. It is expected that as the prototype system is tested, there will be a need to make improvements in order to achieve the most practical and cost effective design. The system initially would be used to inert aircraft fuel tanks during ground operations. At this point, AAR-422 plans to solicit proposals for systems in the spring for a delivery in late FY 2001.

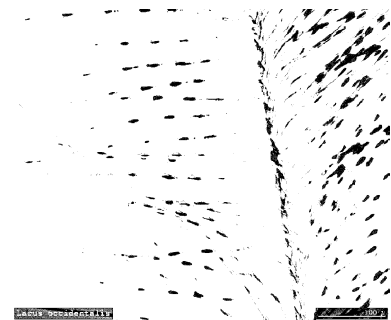
Subsequent work with the B-747 SP would support the development of an OBIGGS system that would inert fuel tanks in-flight after the protection provided by GBI is expanded. Also, the applicability of OBIGGS for cargo compartment inerting, as a means of offsetting the weight/cost of fuel tank inerting, will be explored. The B-747 SP could support other R&D programs undertaken by AAR-400 such as aging systems, specifically wiring.

William M. Cavage, AAR-422, (609) 485-4993

Bird Feather Identification

As part of the Wildlife Strike Mitigation research, the AAR-410 is supporting the development of advanced bird identification techniques at the Smithsonian Institution located in Washington, DC. Positive bird identification is typically performed using bird remains and bird feathers and comparing these against one of the world's largest database of bird feathers, maintained by the Smithsonian Institution. The nodes and internodes of a feather barbule are commonly known as a feather strand.

These capabilities were fully utilized to determine one of the possible causes of a real-time event that occurred in late summer of 2000 which was widely reported by the news media.



The Nodes and Internodes Of a Feather Barbule



Engine Part That Detached From KLM B-747
After A Bird Strike

On August 27, 2000, a KLM Boeing 747 departed from the Los Angeles International airport with 449 passengers on board. The departure path passed over Dockweiler State Beach, located at the end of runway 25 R. Soon after take-off, at 500 ft above ground level (AGL), two distinct loud bangs were heard and fire was observed coming out of the #3 engine. Witnesses reported seeing parts of the engine falling off. The outer cylinder of the engine exhaust nozzle landed on the beach about 35 ft from people. The flight crew declared an emergency, jettisoned



Damages Incurred by the Fan Blades After a Bird
Strike.

166,000 lbs of fuel and returned safely to the airport.

First news reports theorized that the incident might have been caused by a bird strike. However since no birds were observed nor any bird carcass found on the ground, the theory of a bird strike was discarded by the news media after a few days. During the NTSB investigation, however, small amounts of debris resembling feather down and bone fragment were found. These remains were sent to the Smithsonian Institution and were positively identified as being those of a Western Gull, a species with a mean body mass of 2.25 lbs. It is noteworthy that the damaged engine (GE CFS-50E2) is certified to withstand a four pound bird ingestion with no uncontained failure.

Such events illustrate the practical applications of the research conducted under the Wildlife Strike Research Mitigation program. In the bird identification area, current efforts are under way to develop a database of DNA samples from the most commonly struck birds, and it is envisioned that in the future, DNA sequencing will be used, when necessary, to positively identify bird remains.

Dr. Michel Hovan, AAR-410, (609) 485-5552

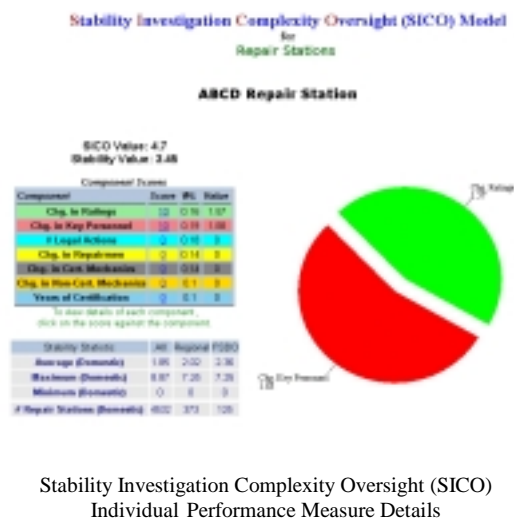
Repair Station Research Initiatives

Federal Aviation Regulation (FAR) Part 145 - Repair stations are defined as those facilities that performs maintenance and/or alterations on airframes, powerplants, propellers, and/or appliances. In the United States aviation industry today, the bulk of maintenance is outsourced, primarily to repair stations. Compared to a few years past, when the major carriers conducted up to 90% of their maintenance in-house, today, only 55% of maintenance is done in-house, and the trends indicate that in the future, even less will be done in-house. Due to the rapidly changing environment in the aviation maintenance arena, changes in the repair station business practices, and advances in aircraft technology, it has become increasingly difficult to administer the FAR Part 145 Repair Stations based on the existing regulations and associated systems. This research effort, sponsored by FAA Flight Standards (AFS), involves developing methods to identify the information required of AFS personnel in providing the required oversight of certificated repair stations. Emphasis will be given to the System Safety business approaches that AFS is embracing. One such task will be to develop models that indicate risk using existing information. Another tool will be created which will help to define future requirements, which may be needed for an effective systems safety approach for repair stations. Consequently, the result has been two parallel tasks that will help to capture

these needs, the repair station risk model, and the repair station functional and certification models. These tasks will feed into the information requirements study.

Repair Station Information Requirements — The goal is to develop a Repair Station Information Requirements Document that identifies all the areas that need improvement to keep pace with state-of-the-art aviation maintenance practices in the industry. The proposed methodology involves interviews of field inspectors, surveys of industry, exploratory analysis of systems with respect to FAA regulations, study of related efforts by other entities, and inputs from subject matter experts (SME).

Some of the benefits of this effort are: improvement in data quality, improvement in systems, and improvement in guidance and training materials. This would in turn provide a means to develop better analysis tools to proactively respond to maintenance related issues and enhance safety. Two efforts that will play a role in the development of this document are the Repair Station Risk Model and the Repair Station Functional and Certification Models.



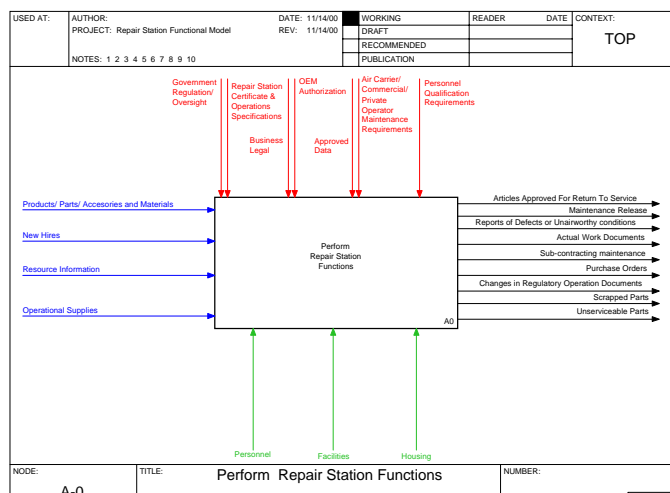
Repair Station Risk Model — The key objectives of the Repair Station Risk Model, pertaining to FAR 145 Repair Stations, are to identify repair stations that may present a greater safety risk, highlight potential risk areas, and to identify those areas that could further improve the risk models as new data is collected.



This is accomplished by dividing the overall Risk Model into four components: Stability, Investigation, Complexity, and Oversight (SICO). Each component is comprised of a set of factors, which, using an algorithm, creates individual performance measures. A further drill down on each factor displays the underlying data. These performance measures, based on results from a condition, event or series of events, or combination thereof will act as a gauge with which the behavior of a certificate holder can be measured. Each of these performance measures will then be incorporated and create an overall risk value.

The various factors are identified, analyzed, and incorporated into the Risk Model by closely working with the subject matter experts of the Repair Station Expert Panel and a team of analysts.

Repair Station Functional and Certification Model — The foundation for an effective systems safety approach is requirements analysis, to determine the capabilities that a repair station oversight system must have, and functional analysis, to describe the operations structure of a repair station. Important aspects of the functional analysis are a description of the elements of the repair station's operations process and an analysis of the relationship between these elements. These analyses form the foundation or basic architecture upon which other task areas – hazard analysis, performance measure and risk indicator design – are based. The output of a functional analysis is a system-engineering model, using the Integrated



Repair Station Functional Model

Definition Functional Modeling Technique, which presents in graphical format the major processes of the system, identifying inputs, outputs, resources, and constraints.

The Repair Station Functional Model is a system-engineering model of the generic functions of FAR Part 145 repair station operations. The Foreign and Domestic FAR Part 145 Certification Process are system-engineering models of the certification process of a FAR Part 145 repair station.

These models are critical for understanding the impact of change related to FAA and repair station activities, and the interactions among the elements of

the repair stations and other programs. It is hoped that an accurate descriptive functional model will enable repair stations and the FAA to interact more effectively on safety management matters.

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FAA-AANC NOTES

Commuter NDI Program — The Federal Aviation Administration Airworthiness Assurance NDI Validation Center (AANC) is teaming with Northwestern University on the development of a new ultrasonic crack detection inspection technique, focused on commuter applications in use to look for cracks along fastener sites in a multi-layer material stack-up. The inspection technique is currently used for detecting cracks in the third layer of material on the lower wing spar of the Fairchild Metro II, SA227 aircraft. This area is difficult to access using the existing eddy current (EC) inspection technique that can only be applied from inside the wing. Thus, the EC method is tedious and more difficult to implement. A hand scanning ultrasonic inspection system has been designed, fabricated, and is in the final stages of validation testing. This system can inspect through all three layers and can be applied on the outside of the wing. Recently, this ultrasonic device was tested on several S227 aircraft at the Fairchild maintenance facility in San Antonio, TX. This provided a good sampling of different aircraft with respect to flight hours and inspection variations (fastener type and painted or unpainted wing surfaces) that will be encountered in the field. The Fairchild representatives were pleased with the new inspection technique and the ability to produce proper flaw detection from the inspection data. The inspections included both the sealant detection and crack detection modes. The sealant inspection is required to insure that the ultrasonic signal is penetrating to the appropriate layer of material. The remaining activities are to complete the final field validation of the new technique and to integrate a new procedure into the appropriate original equipment manufacturer (OEM) documentation.

Kirk Rackow, AANC, (505) 845-9204.

Visual Inspection Reliability Program — The AANC is currently analyzing the data collected from their most recent visual inspection study, whose goal was to explore the effects of instructions on visual inspection performance and reliability. Forty-two inspectors from seven organizations (5 airlines, 1 cargo operator, 1 repair station) participated in the study, which was conducted using the FAA's Boeing 737 Testbed. Six versions of work instructions were developed, based on actual airline work cards, for each of

six on-aircraft inspection tasks. These instruction versions vary in the number and types of directed call-outs. Each inspector conducted all six inspections, and used each instruction type once, over the course of their two-day participation. The calls made by the inspector are being analyzed to determine the impact of varying instruction content on search strategy and inspection performance. A final report on this study is expected in Spring 2001

Caren Wenner, AANC (505) 284-5220.

Rotorcraft Training and Beta Site Testing at PHI — The AANC and Bell Helicopter provided training to six inspectors at Petroleum Helicopter Inc. (PHI). Instruction was provided on the use of a dual frequency eddy current (EC) inspection technique for the detection of 1st, 2nd, and 3rd layer corrosion. This activity follows a successful probability of flaw detection study that demonstrated the ability of dual frequency EC to reliably locate 5% - 10% corrosion in thin skin members (0.016" – 0.032") commonly found in rotorcraft construction. The major advantage of the dual frequency EC method is that it allows an inspector to eliminate interfering signals caused by variations in the gap (sealant thickness) between adjacent layers of skin. The signals caused by this varying gap are difficult to discriminate from corrosion when testing. This makes it impossible to inspect beneath the surface skin with a single frequency eddy current instrument. PHI, which operates a fleet of almost 300 helicopters, agreed to serve as beta site evaluator of this inspection method. The beta site program will use dual frequency EC inspections to supplement existing visual inspection requirements. Mechanical measurements on the disassembled joint will then be used to assess the performance of the dual frequency EC method. The long-range plan is to include this EC inspection as an alternate to visual inspections. Associated improvements in flaw detection sensitivity could: 1) increase aircraft safety, 2) eliminate unnecessary disassembly of joints, or 3) provide early corrosion detection to reduce repair costs. Several data points gathered thus far indicate that the dual frequency eddy current technique is accurate in the field and can identify the necessary maintenance in a cost effective manner.



Petroleum Helicopter Inc. Inspectors Applying Dual Frequency Eddy Current Technique for Corrosion Detection in Helicopters

Dennis Roach, AANC, (505) 844-6078.

Infrared (IR) Detection of Ultrasonically Excited Cracks — Work has started on a project at Wayne State University and the AANC to develop a new inspection technology for crack detection. Initial feasibility demonstrations have shown that cracks can be excited using ultrasound and therefore produce heat that is visible in the infrared spectrum. Current efforts are focused on understanding the heating mechanisms and working with potential users to identify appropriate inspection applications. Interest in this work has come from Boeing, United, Northwest Airlines and General Electric.

Mike Ashbaugh, AANC, (505) 843-8722.

In Brief

Nondestructive Evaluation — On February 1, members of AAR-431, Airframe Structures Section, visited the Nondestructive Evaluation (NDE) Sciences Branch of the NASA Langley Research Center in Hampton, VA, to receive training and to acquire a Rotating Eddy Current Probe system. This advanced NDE method was developed and patented by NASA to inspect for small cracks under rivet heads. The Rotating Eddy Current Probe system is user friendly and has 90% probability of detection (POD) for hidden cracks under rivets with a length of 0.032 inches. The Rotating Eddy Current Probe system will be used for the upcoming test to study multiple crack formation, distribution and first link-up during fatigue loading of a full-scale fuselage lap joint curved panel. Testing will be conducted using the Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) facility located and operated at the FAA William J. Hughes Technical Center.

John Bakuckas, AAR-431, (609) 485-4784

Winter Friction Testing — Keith Bagot, Jim Patterson, and Jim White, AAR-411, participated in the Joint Winter Runway Friction Measurement Program in North Bay, Ontario, during the week of January 29 - February 2. The team was part of an international group numbering 40. The FAA, NASA, and Transport Canada jointly organize and execute a series of experiments and tests to better understand the nature of runways contaminated with ice, snow, chemicals, and abrasives. One of the objectives is to develop a means to measure the surface characteristics - friction, temperature, and classification of contaminant - and develop tools to predict aircraft braking ability. This year's program included six ground test vehicles, including the FAA's Runway Friction Tester (RFT) and a Dash 8 airplane. Over 600 tests were conducted with the ground vehicles (approximately 45 with the RFT) and 44 test runs with the Dash 8. The typical test run required the FAA team to accelerate the test vehicle to 40 mph on runway sections covered with ice and snow and record instantaneous friction. Data analysis will continue through the next several months.

Jim White, AAR-411, (609) 485-5138

Development of Improved Insulation Fire Tests — Final Report DOT/FAA/AR-99/44, "Development of Improved Flammability Criteria for Aircraft Thermal Acoustic Insulation", authored by Tim Marker, AAR-422, was printed and distributed. This important report documents the extensive small, intermediate, and full-scale fire tests conducted in order to develop new, improved flammability test standards for aircraft thermal acoustical insulation. The new tests consist of a radiant panel test that measures in-flight fire ignition resistance and a postcrash fire burnthrough resistance test. The FAA has taken two major regulatory actions to improve insulation fire safety: (1) an airworthiness directive requiring the removal of metallized Mylar™ insulation in over 700 airplanes with replacement by materials that meet the new radiant panel test, and (2) a Notice of Proposed Rulemaking (NPRM) proposing both improved insulation fire tests. The NPRM references the final report as the technical basis for the proposed new fire test criteria.

Gus Sarkos, AAR-422, (609) 485-5620

Personnel Notes

Frank Pecht joins AAR-410 following employment with Galaxy Scientific Corporation. He is working on the data acquisition systems for the National Airport Pavement Test Machine, as well as being responsible for all electronic work in the test facility. Frank is a Navy trained electronics technician who worked for 22 years for the Princeton Plasma Physics Laboratory.

Airport & Aircraft Safety R&D Notes

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